

What is claimed is:

1 1. A color characterization method for
2 characterizing a color imaging system, the method
3 comprising:

4 generating first color values in a color
5 coordinate system by using output samples of the color
6 imaging system, the first color values representing colors
7 of the output samples of the color imaging system; and
8 converting the first color values into second
9 color values in a device-independent color coordinate system
10 using first and second reference values, the first reference
11 values being adjusted using the first color values.

1 2. A color characterization method, according to
2 claim 1, further comprising calculating the second reference
3 values as a function of a medium.

1 3. A color characterization method, according to
2 claim 2, further comprising defining the second reference
3 values as a vector of zeros.

1 4. A color characterization method, according to
2 claim 2, further comprising defining the second reference

3 values using a maximum value in a black channel of the color
4 imaging system and minimum values in at least one additional
5 channel of the color imaging system.

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1 5. A color characterization method, according to
2 claim 2, further comprising defining the second reference
3 values using maximum values in channels of the color imaging
4 system.

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1 6. A color characterization method, according to
2 claim 1, further comprising calculating the first reference
3 values using the second reference values.

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1 67. A color characterization method, according to
2 claim 1, further comprising generating the first color
3 values using at least one of the following: a color
4 measuring device, and a memory.

Sub 502
1 8. A color characterization method for
2 characterizing a color imaging system, the method
3 comprising:
4 generating first color values in a color
5 coordinate system by using output samples of the color

6 imaging system, the first color values representing colors
7 of the output samples;

8 converting the first color values into second
9 color values in a device-independent color coordinate system
10 using first and second reference values;

11 calculating the second reference values as a
12 function of a medium;

13 calculating the first reference values using the
14 second reference values; and

15 adjusting the first reference values using the
16 first color values.

1 9. A color characterization method, according to
2 claim 8, wherein the device-independent color coordinate
3 system uses white reference tristimulus values to compensate
4 for certain perceptual effects.

1 10. A color characterization method, according to
2 claim 9, further comprising:

3 converting the first color values into the second
4 color values using transformations; and

5 adjusting the first reference values using the
6 first color values.

10
1 11. A color characterization method, according to
2 claim 8, wherein the device-independent color coordinate
3 system is an $L^*a^*b^*$ color coordinate system.

1 12. A color characterization method, according to
2 claim 11, further comprising:

3 converting the first color values into the second
4 color values using the equations

5
$$L^* = 116((Y - Y_{bp}) / (Y_n' - Y_{bp}))^{1/3} - 16$$

6
$$a^* = 500[((X - X_{bp}) / (X_n' - X_{bp}))^{1/3} -$$

7
$$((Y - Y_{bp}) / (Y_n' - Y_{bp}))^{1/3}]$$

8
$$b^* = 200[((Y - Y_{bp}) / (Y_n' - Y_{bp}))^{1/3} -$$

9
$$((Z - Z_{bp}) / (Z_n' - Z_{bp}))^{1/3}],$$

10 wherein

11 X, Y, and Z are tristimulus values for the
12 first color values,

13 X_n' , Y_n' , and Z_n' are the first reference
14 values, and

15 X_{bp} , Y_{bp} , and Z_{bp} are the second reference
16 values; and

17 adjusting the first reference values using the
18 tristimulus values.

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1 13. A color characterization method, according to
2 claim 12, further comprising adjusting the first reference
3 values using the equations

4
$$X_n' = X_b(1 - \text{sat}(X, X_{bp}, X_n)) + X_n \cdot \text{sat}(X, X_{bp}, X_n)$$

5
$$Y_n' = Y_b(1 - \text{sat}(Y, Y_{bp}, Y_n)) + Y_n \cdot \text{sat}(Y, Y_{bp}, Y_n)$$

6
$$Z_n' = Z_b(1 - \text{sat}(Z, Z_{bp}, Z_n)) + Z_n \cdot \text{sat}(Z, Z_{bp}, Z_n),$$

7 wherein

8
$$\text{sat}(X, X_{bp}, X_n) = (X - X_n) / (X_{bp} - X_n)$$

9
$$\text{sat}(Y, Y_{bp}, Y_n) = (Y - Y_n) / (Y_{bp} - Y_n)$$

10
$$\text{sat}(Z, Z_{bp}, Z_n) = (Z - Z_n) / (Z_{bp} - Z_n)$$

11 X_n , Y_n , and Z_n are tristimulus values for a perfect
12 white diffuser under standard viewing conditions, and

13 X_b , Y_b , and Z_b are tristimulus values for an
14 imaging base associated with the color imaging system.

1 14. A color characterization method, according to
2 claim 11, further comprising:

3 converting the first color values into the second
4 color values using the equations

5
$$L^* = 116(Y / Y_n')^{1/3} - 16$$

6
$$a^* = 500[(X / X_n')^{1/3} - (Y / Y_n')^{1/3}]$$

7
$$b^* = 200[(Y / Y_n')^{1/3} - (Z / Z_n')^{1/3}],$$

8

~~wherein~~

9

X, Y, and Z are tristimulus values for the

10

first color values, and

11

 X_n' , Y_n' , and Z_n' are the first reference

12

values; and

13

adjusting the first reference values using the

14

tristimulus values.

1

15. A color characterization method, according to

2

claim 14, further comprising adjusting the first reference

3

values using the equations

4

$$X_n' = X_b(1 - \text{sat}(X, X_{\max}, X_n)) + X_n \cdot \text{sat}(X, X_{\max}, X_n)$$

5

$$Y_n' = Y_b(1 - \text{sat}(Y, Y_{\max}, Y_n)) + Y_n \cdot \text{sat}(Y, Y_{\max}, Y_n)$$

6

$$Z_n' = Z_b(1 - \text{sat}(Z, Z_{\max}, Z_n)) + Z_n \cdot \text{sat}(Z, Z_{\max}, Z_n),$$

7

wherein

8

$$\text{sat}(X, X_{\max}, X_n) = (X - X_n) / (X_{\max} - X_n)$$

9

$$\text{sat}(Y, Y_{\max}, Y_n) = (Y - Y_n) / (Y_{\max} - Y_n)$$

10

$$\text{sat}(Z, Z_{\max}, Z_n) = (Z - Z_n) / (Z_{\max} - Z_n)$$

11

 X_n , Y_n , and Z_n are tristimulus values for a perfect

12

white diffuser under standard viewing conditions,

13 X_{\max} , Y_{\max} , and Z_{\max} are tristimulus values for a
14 color having a maximum saturation associated with the color
15 imaging system, and
16 X_b , Y_b , and Z_b are tristimulus values for an
17 imaging base associated with the color imaging system.

1 ¹⁵
2 ¹16. A color characterization method, according to
3 claim 8, further comprising generating the first color
4 values using at least one of the following: a color
5 measuring device, and a memory.

1 17. For use in characterizing a color imaging
2 system, a color characterization arrangement comprising:
3 means for generating first color values in a color
4 coordinate system by using output samples of the color
5 imaging system, the first color values representing colors
6 of the output samples; and
7 means for converting the first color values into
8 second color values in a device-independent color coordinate
9 system using first and second reference values, the first
10 reference values being adjusted using the first color
11 values.

1 18. For use in characterizing a color imaging
2 system, a color characterization arrangement comprising:
3 a computer arrangement, configured and arranged to
4 receive first color values in a color coordinate system, the
5 first color values representing colors of output samples of
6 the color imaging system; and
7 a first memory, responsive to the computer
8 arrangement and configured and arranged to store second
9 color values in a device-independent color coordinate
10 system,
11 the computer arrangement being further configured
12 and arranged to convert the first color values into the
13 second color values using first and second reference values,
14 the first reference values being adjusted using the first
15 color values.

1 19. A color characterization arrangement,
2 according to claim 18, wherein the computer arrangement is
3 further configured and arranged to calculate the second
4 reference values as a function of a medium.

1 20. A color characterization arrangement,
2 according to claim 19, wherein the computer arrangement is

3 further configured and arranged to define the second
4 reference values as a vector of zeros.

1 21. A color characterization arrangement,
2 according to claim 19, wherein the computer arrangement is
3 further configured and arranged to define the second
4 reference values using a maximum value in a black channel of
5 the color imaging system and minimum values in at least one
6 additional channel of the color imaging system.

1 22. A color characterization arrangement,
2 according to claim 19, wherein the computer arrangement is
3 further configured and arranged to define the second
4 reference values using maximum values in channels of the
5 color imaging system.

1 23. A color characterization arrangement,
2 according to claim 18, wherein the computer arrangement is
3 further configured and arranged to calculate the first
4 reference values using the second reference values.

1 24. A color characterization arrangement,
2 according to claim 18, wherein the computer arrangement is

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3 further configured and arranged to adjust the first
4 reference values using the first color values.

5 25. A color characterization arrangement,
6 according to claim 18, wherein the device-independent color
7 coordinate system uses white reference tristimulus values to
8 compensate for certain perceptual effects.

1 26. A color characterization arrangement,
2 according to claim 18, wherein the computer arrangement is
3 further configured and arranged to:
4 convert the first color values into the second
5 color values using transformations; and
6 adjust the first reference values using the first
7 color values.

1 23
27. A color characterization arrangement,
2 according to claim ¹⁷18, wherein the device-independent color
3 coordinate system is an L*a*b* color coordinate system.

1 28. A color characterization arrangement,
2 according to claim 27, wherein the computer arrangement is
3 further configured and arranged to:

4 convert the first color values into the second
5 color values using the equations

6
$$L^* = 116((Y - Y_{bp}) / (Y_n' - Y_{bp}))^{1/3} - 16$$

7
$$a^* = 500[((X - X_{bp}) / (X_n' - X_{bp}))^{1/3} -$$

8
$$((Y - Y_{bp}) / (Y_n' - Y_{bp}))^{1/3}]$$

9
$$b^* = 200[((Y - Y_{bp}) / (Y_n' - Y_{bp}))^{1/3} -$$

10
$$((Z - Z_{bp}) / (Z_n' - Z_{bp}))^{1/3}],$$

11 wherein

12 X, Y, and Z are tristimulus values for the
13 first color values,

14 X_n' , Y_n' , and Z_n' are the first reference
15 values, and

16 X_{bp} , Y_{bp} , and Z_{bp} are the second reference
17 values; and

18 adjust the first reference values using the
19 tristimulus values.

1 29. A color characterization arrangement,
2 according to claim 28, wherein the computer arrangement is
3 further configured and arranged to adjust the first
4 reference values using the equations

5
$$X_n' = X_b(1 - \text{sat}(X, X_{bp}, X_n)) + X_n \cdot \text{sat}(X, X_{bp}, X_n)$$

6
$$Y_n' = Y_b(1 - \text{sat}(Y, Y_{bp}, Y_n)) + Y_n \cdot \text{sat}(Y, Y_{bp}, Y_n)$$

7
$$Z_n' = Z_b(1 - \text{sat}(Z, Z_{bp}, Z_n)) + Z_n \cdot \text{sat}(Z, Z_{bp}, Z_n),$$

8 wherein

9
$$\text{sat}(X, X_{bp}, X_n) = (X - X_n) / (X_{bp} - X_n)$$

10
$$\text{sat}(Y, Y_{bp}, Y_n) = (Y - Y_n) / (Y_{bp} - Y_n)$$

11
$$\text{sat}(Z, Z_{bp}, Z_n) = (Z - Z_n) / (Z_{bp} - Z_n)$$

12 X_n , Y_n , and Z_n are tristimulus values for a perfect
13 white diffuser under standard viewing conditions, and

14 X_b , Y_b , and Z_b are tristimulus values for an
15 imaging base associated with the color imaging system.

1 30. A color characterization arrangement,
2 according to claim 27, wherein the computer arrangement is
3 further configured and arranged to:

4 convert the first color values into the second
5 color values using the equations

6
$$L^* = 116(Y / Y_n')^{1/3} - 16$$

7
$$a^* = 500[(X / X_n')^{1/3} - (Y / Y_n')^{1/3}]$$

8
$$b^* = 200[(Y / Y_n')^{1/3} - (Z / Z_n')^{1/3}],$$

9 wherein

10 X , Y , and Z are tristimulus values for the
11 first color values, and

12 X_n' , Y_n' , and Z_n' are the first reference
13 values; and
14 adjust the first reference values using the
15 tristimulus values.

1 31. A color characterization arrangement,
2 according to claim 30, wherein the computer arrangement is
3 further configured and arranged to adjust the first
4 reference values using the equations

5
$$X_n' = X_b(1 - \text{sat}(X, X_{\max}, X_n)) + X_n \cdot \text{sat}(X, X_{\max}, X_n)$$

6
$$Y_n' = Y_b(1 - \text{sat}(Y, Y_{\max}, Y_n)) + Y_n \cdot \text{sat}(Y, Y_{\max}, Y_n)$$

7
$$Z_n' = Z_b(1 - \text{sat}(Z, Z_{\max}, Z_n)) + Z_n \cdot \text{sat}(Z, Z_{\max}, Z_n),$$

8 wherein

9
$$\text{sat}(X, X_{\max}, X_n) = (X - X_n) / (X_{\max} - X_n)$$

10
$$\text{sat}(Y, Y_{\max}, Y_n) = (Y - Y_n) / (Y_{\max} - Y_n)$$

11
$$\text{sat}(Z, Z_{\max}, Z_n) = (Z - Z_n) / (Z_{\max} - Z_n)$$

12 X_n , Y_n , and Z_n are tristimulus values for a perfect
13 white diffuser under standard viewing conditions,

14 X_{\max} , Y_{\max} , and Z_{\max} are tristimulus values for a
15 color having a maximum saturation associated with the color
16 imaging system, and

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17 X_b , Y_b , and Z_b are tristimulus values for an
18 imaging base associated with the color imaging system.

1 ²⁸
32. A color characterization arrangement,
2 according to claim ¹⁷18, further comprising a second memory,
3 configured and arranged to provide the first color values to
4 the computer arrangement.

1 ²⁹
33. A color characterization arrangement,
2 according to claim ¹⁷18, further comprising a color measuring
3 instrument, configured and arranged to:
4 obtain the first color values from a sample; and
5 provide the first color values to the computer
6 arrangement.

1 34. For use in characterizing a color imaging
2 system, a data storage medium storing a computer-executable
3 program configured and arranged to, when executed,
4 obtain first color values in a color coordinate
5 system by using output samples of the color imaging system,
6 the first color values representing colors of the output
7 samples, and

8 convert the first color values into second color
9 values in a device-independent color coordinate system using
10 first and second reference values, the first reference
11 values being adjusted using the first color values.

1 35. A data storage medium, according to claim 34,
2 wherein the computer-executable program is further
3 configured and arranged to, when executed, calculate the
4 second reference values as a function of a medium.

1 36. A data storage medium, according to claim 35,
2 wherein the computer-executable program is configured and
3 arranged to, when executed, define the second reference
4 values as a vector of zeros.

1 37. A data storage medium, according to claim 35,
2 wherein the computer-executable program is configured and
3 arranged to, when executed, define the second reference
4 values using a maximum value in a black channel of the color
5 imaging system and minimum values in at least one additional
6 channel of the color imaging system.

1 38. A data storage medium, according to claim 35,
2 wherein the computer-executable program is configured and
3 arranged to, when executed, define the second reference
4 values using maximum values in channels of the color imaging
5 system.

1 39. A data storage medium, according to claim 34,
2 wherein the computer-executable program is further
3 configured and arranged to, when executed, calculate the
4 first reference values using the second reference values.

1 40. A data storage medium, according to claim 34,
2 wherein the computer-executable program is further
3 configured and arranged to, when executed, adjust the first
4 reference values using the first color values.

5 41. A data storage medium, according to claim 34,
6 wherein the device-independent color coordinate system uses
7 white reference tristimulus values to compensate for certain
8 perceptual effects.

1 42. A data storage medium, according to claim 41,
2 wherein the computer-executable program is further
3 configured and arranged to, when executed,
4 convert the first color values into the second
5 color values using transformations; and
6 adjust the first reference values using the first
7 color values.

1 37 43. A data storage medium, according to claim 34,
2 wherein the device-independent color coordinate system is an
3 L*a*b* color coordinate system.

1 44. A data storage medium, according to claim 43,
2 wherein the computer-executable program is further
3 configured and arranged to, when executed,
4 convert the first color values into the second
5 color values using the equations

$$L^* = 116((Y - Y_{bp}) / (Y_n' - Y_{bp}))^{1/3} - 16$$

$$a^* = 500[((X - X_{bp}) / (X_n' - X_{bp}))^{1/3} - ((Y - Y_{bp}) / (Y_n' - Y_{bp}))^{1/3}]$$

$$b^* = 200[((Y - Y_{bp}) / (Y_n' - Y_{bp}))^{1/3} - ((Z - Z_{bp}) / (Z_n' - Z_{bp}))^{1/3}],$$

11

~~wherein~~

12

X, Y, and Z are tristimulus values for the

13

first color values,

14

 X_n' , Y_n' , and Z_n' are the first reference

15

values, and

16

 X_{bp} , Y_{bp} , and Z_{bp} are the second reference

17

values, and

18

adjust the first reference values using the

19

tristimulus values.

1

45. A data storage medium, according to claim 44,

2

wherein the computer-executable program is further

3

configured and arranged to, when executed, adjust the first

4

reference values using the equations

5

$$X_n' = X_b(1 - \text{sat}(X, X_{bp}, X_n)) + X_n \cdot \text{sat}(X, X_{bp}, X_n)$$

6

$$Y_n' = Y_b(1 - \text{sat}(Y, Y_{bp}, Y_n)) + Y_n \cdot \text{sat}(Y, Y_{bp}, Y_n)$$

7

$$Z_n' = Z_b(1 - \text{sat}(Z, Z_{bp}, Z_n)) + Z_n \cdot \text{sat}(Z, Z_{bp}, Z_n),$$

8

wherein

9

$$\text{sat}(X, X_{bp}, X_n) = (X - X_n) / (X_{bp} - X_n)$$

10

$$\text{sat}(Y, Y_{bp}, Y_n) = (Y - Y_n) / (Y_{bp} - Y_n)$$

11

$$\text{sat}(Z, Z_{bp}, Z_n) = (Z - Z_n) / (Z_{bp} - Z_n)$$

12 X_n , Y_n , and Z_n are tristimulus values for a perfect
13 white diffuser under standard viewing conditions, and
14 X_b , Y_b , and Z_b are tristimulus values for an
15 imaging base associated with the color imaging system.

1 46. A data storage medium, according to claim 43,
2 wherein the computer-executable program is further
3 configured and arranged to, when executed,

4 convert the first color values into the second
5 color values using the equations

6
$$L^* = 116(Y / Y_n')^{1/3} - 16$$

7
$$a^* = 500[(X / X_n')^{1/3} - (Y / Y_n')^{1/3}]$$

8
$$b^* = 200[(Y / Y_n')^{1/3} - (Z / Z_n')^{1/3}],$$

9 wherein

10 X , Y , and Z are tristimulus values for the
11 first color values, and

12 X_n' , Y_n' , and Z_n' are the first reference
13 values, and

14 adjust the first reference values using the
15 tristimulus values.

1 47. A data storage medium, according to claim 46,
2 wherein the computer-executable program is further
3 configured and arranged to, when executed, adjust the first
4 reference values using the equations

5
$$X_n' = X_b(1 - \text{sat}(X, X_{\max}, X_n)) + X_n \cdot \text{sat}(X, X_{\max}, X_n)$$

6
$$Y_n' = Y_b(1 - \text{sat}(Y, Y_{\max}, Y_n)) + Y_n \cdot \text{sat}(Y, Y_{\max}, Y_n)$$

7
$$Z_n' = Z_b(1 - \text{sat}(Z, Z_{\max}, Z_n)) + Z_n \cdot \text{sat}(Z, Z_{\max}, Z_n),$$

8 wherein

9
$$\text{sat}(X, X_{\max}, X_n) = (X - X_n) / (X_{\max} - X_n)$$

10
$$\text{sat}(Y, Y_{\max}, Y_n) = (Y - Y_n) / (Y_{\max} - Y_n)$$

11
$$\text{sat}(Z, Z_{\max}, Z_n) = (Z - Z_n) / (Z_{\max} - Z_n)$$

12 X_n , Y_n , and Z_n are tristimulus values for a perfect
13 white diffuser under standard viewing conditions,

14 X_{\max} , Y_{\max} , and Z_{\max} are tristimulus values for a
15 color having a maximum saturation associated with the color
16 imaging system, and

17 X_b , Y_b , and Z_b are tristimulus values for an
18 imaging base associated with the color imaging system.

1 42 48. A data storage medium, according to claim 34, 30
2 wherein the computer-executable program is further

3 configured and arranged to, when executed, store the second
4 color values in a memory.

1 49. A color transformation method for performing
2 a color transformation between first and second color
3 imaging systems, the color transformation method comprising:

4 generating first and second color values by using
5 output samples of the first and second color imaging
6 systems, the first and second color values respectively
7 representing colors of the output samples of the first and
8 second color imaging systems;

9 converting the first and second color values
10 respectively into third and fourth color values using a
11 device-independent color coordinate system;

12 calculating first reference values from a medium
13 and second reference values from the first reference values;

14 adjusting the second reference values using the
15 first and second color values; and

16 generating color transformation values using the
17 third and fourth color values.

1 50. A color characterization method, according to
2 claim 49, wherein the device-independent color coordinate

3 system uses white reference tristimulus values to compensate
4 for certain perceptual effects.

1 51. A color characterization method, according to
2 claim 50, further comprising:

3 converting the first color values into the second
4 color values using transformations; and

5 adjusting the first reference values using the
6 first color values.

1 ⁴⁶
52. A color transformation method, according to
2 claim ⁴³~~49~~, wherein the color coordinate system is an L*a*b*
3 color coordinate system.

1 53. A color transformation method, according to
2 claim 52, further comprising:

3 converting the first color values into the third
4 color values using the equations

5
$$L^* = 116((Y_1 - Y_{bp1}) / (Y_{n1}' - Y_{bp1}))^{1/3} - 16$$

6
$$a^* = 500[(((X_1 - X_{bp1}) / (X_{n1}' - X_{bp1}))^{1/3} -$$

7
$$((Y_1 - Y_{bp1}) / (Y_{n1}' - Y_{bp1}))^{1/3})]$$

8
$$b^* = 200[(((Y_1 - Y_{bp1}) / (Y_{n1}' - Y_{bp1}))^{1/3} -$$

9
$$((Z_1 - Z_{bp1}) / (Z_{n1}' - Z_{bp1}))^{1/3})],$$

10 wherein

11 X_1 , Y_1 , and Z_1 are tristimulus values for the
12 first color values,

13 X_{bp1} , Y_{bp1} , and Z_{bp1} are black tristimulus
14 values for the first color imaging system, and

15 X_{n1} , Y_{n1} , and Z_{n1} are white reference
16 tristimulus values for the first color imaging system;

17 converting the second color values into the fourth
18 color values using the equations

19
$$L^* = 116((Y_2 - Y_{bp2}) / (Y_{n2} - Y_{bp2}))^{1/3} - 16$$

20
$$a^* = 500[(((X_2 - X_{bp2}) / (X_{n2} - X_{bp2}))^{1/3} -$$

21
$$((Y_2 - Y_{bp2}) / (Y_{n2} - Y_{bp2}))^{1/3})]$$

22
$$b^* = 200[(((Y_2 - Y_{bp2}) / (Y_{n2} - Y_{bp2}))^{1/3} -$$

23
$$((Z_2 - Z_{bp2}) / (Z_{n2} - Z_{bp2}))^{1/3})],$$

24 wherein

25 X_2 , Y_2 , and Z_2 are tristimulus values for the
26 second color values,

27 X_{bp2} , Y_{bp2} , and Z_{bp2} are black tristimulus
28 values for the second color imaging system, and

29 X_{n2} , Y_{n2} , and Z_{n2} are white tristimulus
30 values for the second color imaging system; and

31 adjusting the second reference values using the
32 black tristimulus values for the first and second color
33 imaging systems.

1 ⁴⁸54. A color transformation method, according to
2 ⁴⁷claim 53, further comprising:

3 adjusting the white reference tristimulus values
4 for the first color imaging system using the equations

$$X_{n1}' = X_{b1}(1 - \text{sat}(X_1, X_{bp1}, X_{n1})) + X_{n1} \cdot$$

$$\text{sat}(X_1, X_{bp1}, X_{n1})$$

$$Y_{n1}' = Y_{b1}(1 - \text{sat}(Y_1, Y_{bp1}, Y_{n1})) + Y_{n1} \cdot$$

$$\text{sat}(Y_1, Y_{bp1}, Y_{n1})$$

$$Z_{n1}' = Z_{b1}(1 - \text{sat}(Z_1, Z_{bp1}, Z_{n1})) + Z_{n1} \cdot$$

$$\text{sat}(Z_1, Z_{bp1}, Z_{n1}),$$

wherein

$$\text{sat}(X_1, X_{bp}, X_n) = (X_1 - X_{n1}) / (X_{bp1} - X_{n1})$$

$$\text{sat}(Y_1, Y_{bp}, Y_n) = (Y_1 - Y_{n1}) / (Y_{bp1} - Y_{n1})$$

$$\text{sat}(Z_1, Z_{bp1}, Z_{n1}) = (Z_1 - Z_{n1}) / (Z_{bp1} - Z_{n1})$$

15 X_{n1} , Y_{n1} , and Z_{n1} are tristimulus values for a
16 perfect white diffuser associated with the first color
17 imaging system under standard viewing conditions, and

1 55. A color characterization method, according to
2 claim 52, further comprising:

3 converting the first color values into the third
4 color values using the equations

5
$$L^* = 116(Y_1 / Y_{n1}')^{1/3} - 16$$

6
$$a^* = 500[(X_1 / X_{n1}')^{1/3} - (Y_1 / Y_{n1}')^{1/3}]$$

7
$$b^* = 200[(Y_1 / Y_{n1}')^{1/3} - (Z_1 / Z_{n1}')^{1/3}],$$

8 wherein

9 X_1 , Y_1 , and Z_1 are tristimulus values for the
10 first color values, and

11 X_{n1}' , Y_{n1}' , and Z_{n1}' are white reference
12 tristimulus values for the first color imaging system;

13 converting the second color values into the fourth
14 color values using the equations

15
$$L^* = 116(Y_2 / Y_{n2}')^{1/3} - 16$$

16
$$a^* = 500[(X_2 / X_{n2}')^{1/3} - (Y_2 / Y_{n2}')^{1/3}]$$

17
$$b^* = 200[(Y_2 / Y_{n2}')^{1/3} - (Z_2 / Z_{n2}')^{1/3}],$$

18 wherein

19 X_2 , Y_2 , and Z_2 are tristimulus values for the
20 second color values, and

21 X_{n2}' , Y_{n2}' , and Z_{n2}' are white reference

22 tristimulus values for the second color imaging system; and

23 adjusting the first reference values using the
24 black tristimulus values for the first and second color
25 imaging systems.

1 ⁵⁰
2 ⁴⁹ 56. A color transformation method, according to
claim 55, further comprising:

3 adjusting the white reference tristimulus values
4 for the first color imaging system using the equations

5
$$X_{n1}' = X_{b1} (1 - \text{sat}(X_1, X_{\text{max}1}, X_{n1})) +$$

6
$$X_{n1} \cdot \text{sat}(X_1, X_{\text{max}1}, X_{n1})$$

7
$$Y_{n1}' = Y_{b1} (1 - \text{sat}(Y_1, Y_{\text{max}1}, Y_{n1})) +$$

8
$$Y_{n1} \cdot \text{sat}(Y_1, Y_{\text{max}1}, Y_{n1})$$

9
$$Z_{n1}' = Z_{b1} (1 - \text{sat}(Z_1, Z_{\text{max}1}, Z_{n1})) +$$

10
$$Z_{n1} \cdot \text{sat}(Z_1, Z_{\text{max}1}, Z_{n1}),$$

11 wherein

12
$$\text{sat}(X_1, X_{\text{max}1}, X_{n1}) = (X_1 - X_{n1}) / (X_{\text{max}1} - X_{n1})$$

13
$$\text{sat}(Y_1, Y_{\text{max}1}, Y_{n1}) = (Y_1 - Y_{n1}) / (Y_{\text{max}1} - Y_{n1})$$

14
$$\text{sat}(Z_1, Z_{\text{max}1}, Z_{n1}) = (Z_1 - Z_{n1}) / (Z_{\text{max}1} - Z_{n1})$$

15 X_{n1} , Y_{n1} , and Z_{n1} are tristimulus values for a
16 perfect white diffuser associated with the first color
17 imaging system under standard viewing conditions,

18 $X_{\max 1}$, $Y_{\max 1}$, and $Z_{\max 1}$ are tristimulus values for a
19 color having a maximum saturation associated with the first
20 color imaging system, and

21 X_{b1} , Y_{b1} , and Z_{b1} are tristimulus values for an
22 imaging base associated with the first color imaging system;
23 and

24 adjusting the white reference tristimulus values
25 for the second color imaging system using the equations

26
$$X_{n2}' = X_{b2}(1 - \text{sat}(X_2, X_{\max 2}, X_{n2})) +$$

27
$$X_{n2} \cdot \text{sat}(X_2, X_{\max 2}, X_{n2})$$

28
$$Y_{n2}' = Y_{b2}(1 - \text{sat}(Y_2, Y_{\max 2}, Y_{n2})) +$$

29
$$Y_{n2} \cdot \text{sat}(Y_2, Y_{\max 2}, Y_{n2})$$

30
$$Z_{n2}' = Z_{b2}(1 - \text{sat}(Z_2, Z_{\max 2}, Z_{n2})) +$$

31
$$Z_{n2} \cdot \text{sat}(Z_2, Z_{\max 2}, Z_{n2}),$$

32 wherein

33
$$\text{sat}(X_2, X_{\max 2}, X_{n2}) = (X_2 - X_{n2}) / (X_{\max 2} - X_{n2})$$

34
$$\text{sat}(Y_2, Y_{\max 2}, Y_{n2}) = (Y_2 - Y_{n2}) / (Y_{\max 2} - Y_{n2})$$

35
$$\text{sat}(Z_2, Z_{\max 2}, Z_{n2}) = (Z_2 - Z_{n2}) / (Z_{\max 2} - Z_{n2})$$

36 X_{n2} , Y_{n2} , and Z_{n2} are tristimulus values for a
37 perfect white diffuser associated with the second color
38 imaging system under standard viewing conditions,

39 $X_{\max 2}$, $Y_{\max 2}$, and $Z_{\max 2}$ are tristimulus values for a
40 color having a maximum saturation associated with the second
41 color imaging system, and

42 X_{b2} , Y_{b2} , and Z_{b2} are tristimulus values for an
43 imaging base associated with the second color imaging
44 system.

1 57. For use in performing a color transformation
2 between first and second color imaging systems, a color
3 transformation arrangement comprising:

4 means for generating first color values by using
5 output samples of the first color imaging system, the first
6 color values representing colors of the output samples of
7 the first color imaging system;

8 means for generating second color values by using
9 output samples of the second color imaging system, the
10 second color values representing colors of the output
11 samples of the second color imaging system;

12 means for converting the first color values into
13 third color values using a color coordinate system;

14 means for converting the second color values into
15 fourth color values using the color coordinate system;

